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No. 51, December 1982

U.S. Intervention in the  
Exchange Market for DM, 1977-80

Paul Wonnacott

INTERNATIONAL FINANCE SECTION  
DEPARTMENT OF ECONOMICS  
PRINCETON UNIVERSITY

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IN INTERNATIONAL FINANCE

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## CONTENTS

1	INTRODUCTION	1
2	U.S. INTERVENTION IN THE MARKET FOR DM: LEANING AGAINST THE WIND?	3
3	WHAT IS "STABILIZING" INTERVENTION? The Effects of Intervention on the Exchange Rate Leaning Against the Wind and Exchange-Rate Stabilization A Digression on Borrowing	9 11 14 16
4	WAS U.S. INTERVENTION STABILIZING? INTERVENTION AND THE 12-MONTH MOVING AVERAGE	17
5	DID THE AUTHORITIES "OUTPREDICT" THE MARKET?	21
6	INTERVENTION POLICY: A TENTATIVE SUGGESTION	31
7	CONCLUSIONS	32
	REFERENCES	33

## LIST OF TABLES

1. Intervention and Exchange-Rate Changes	7
2. Percentage of Intervention in the Stabilizing Direction	18
3. Intervention and Deviations of the Exchange Rate from Its Moving Average	19
4. Intervention and Errors in the Forward Rate	23
5. Stabilizing Intervention and <i>DFMA</i> ,	26
6. Specific Outpredictions?	29
7. Inefficient Markets?	30

## LIST OF FIGURES

1. Intervention and Daily Exchange-Rate Changes, October 1977–March 1980	4
2. The Dollar in Terms of the DM, October 1977–December 1979	6
3. Leaning Against the Wind	15
4. Deviations from the Moving Average and from the Forecast Moving Average, October 1977–December 1979	25
5. Intervention and Deviations from the Forecast Moving Average	27

## 1 INTRODUCTION

Exchange-market intervention by national treasuries and central banks is a controversial topic, centering on two related issues: (1) Are authorities capable of intervening in exchange markets in such a way as to stabilize them? (2) If the authorities are indeed capable of stabilizing the exchange rate, should they attempt to do so? The primary purpose of this study is to investigate the first of these questions by examining U.S. official intervention in the market for the Deutsche Mark (DM). This investigation leads to tentative suggestions for future intervention strategy.

We look at daily data for the period starting on October 1, 1977, and ending two and a half years later, on March 31, 1980. The last quarter of 1977 was chosen as the beginning point because sizable intervention recommenced then, after several years of very limited intervention. The end point was dictated by the availability of data during my period on the Treasury staff. During this period, U.S. intervention averaged \$42.5 million per business day. Of the 618 business days, intervention occurred on something less than half (284 days), and average intervention on those days was \$92.6 million. This study is based solely on U.S. data and takes no account of German intervention.

In addition to the main question, whether intervention was stabilizing, several related issues are studied:

a. Did U.S. intervention in the market for the DM during this period conform to the general pattern that has been observed for official intervention by many countries—resisting movements in exchange rates, or leaning against the wind?

b. Is there evidence that the authorities outpredicted the market when they intervened?

c. Is there evidence of inefficiency in the market for the DM during this period?

This study is divided into seven chapters. Chapter 2 considers not only question (a), whether the U.S. authorities followed the strategy of leaning against the wind, but also the relationship between leaning against the wind and exchange-rate stabilization. This discussion raises a fundamental question about the meaning of stabilization. That question is addressed in Chapter 3. Chapter

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4 constitutes the core of the study. It considers whether the U.S. authorities behaved in a stabilizing manner. Chapter 5 addresses questions (b) and (c), concerning evidence of official outprediction of the market and of market inefficiency. Chapter 6 puts forward a tentative suggestion for an intervention strategy, and Chapter 7 presents tentative conclusions.



## 2 U.S. INTERVENTION IN THE MARKET FOR DM: LEANING AGAINST THE WIND?

Three related objectives have been ascribed to official intervention: to combat disorderly conditions in exchange markets, to smooth exchange-rate movements, and, on occasion, to correct an exchange rate that is considered inappropriate.

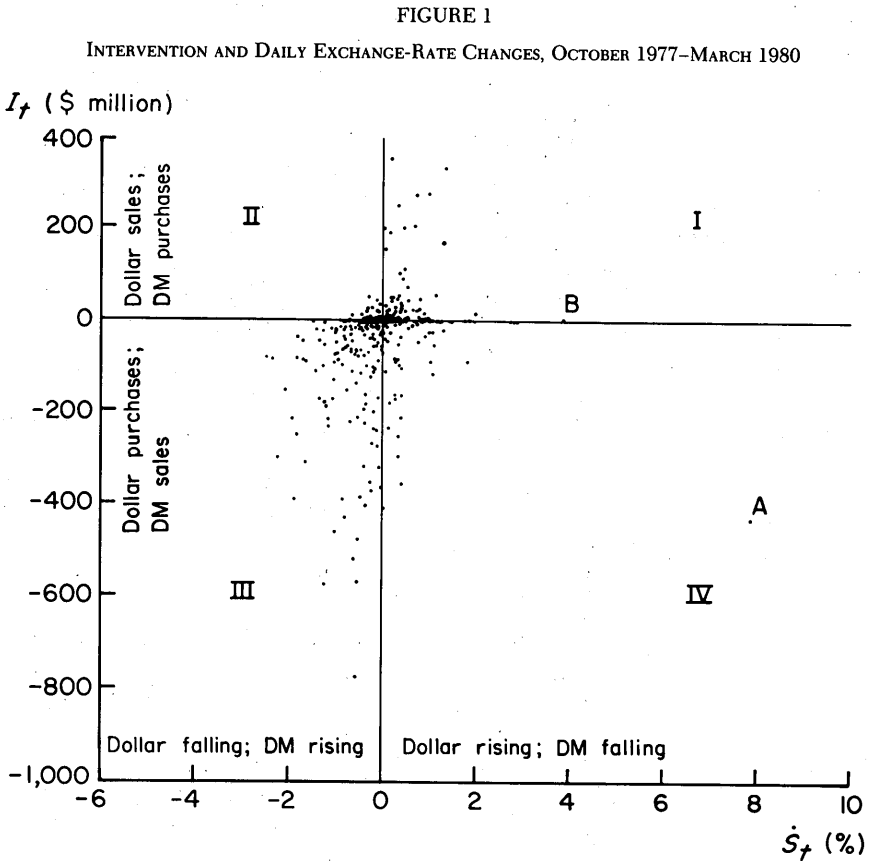
It is hard to get a handle on the concept of a "disorderly market," since whether or not a market is disorderly seems to depend on a subjective evaluation by market participants. It is sometimes said that a disorderly market cannot be defined but that traders know one when they see one. When pressed, those who hold this view suggest that a disorderly market is characterized by a rapid change in the rate. Volume may be high, as market participants jump on a bandwagon; or it may be very low, as they withdraw from the market because of uncertainties. Another characteristic may be a large spread between buy and sell quotations.

The main purpose of most of the nascent empirical literature on official exchange-market intervention has been to get good equations to explain the intervention behavior of the various national authorities—that is, to get good statistical fits. Examples of this literature can be found in the work by Artus (1976) on Germany, Black (1980) on the G-10 countries, Longworth (1980) on Canada, and Quirk (1977) on Japan, and in the papers by Clark (1979), Hernandez-Cata (1979), and Howe (1978), which contribute to the Federal Reserve Board's multi-country model. In some cases, an explanation of intervention behavior has been sought in order to complete larger models (notably, the Fed's multi-country model). Although the purposes of this literature are quite different from our objective of evaluating intervention, it is nevertheless a good place to begin.

A number of explanatory variables appear in the literature. For example, Black (1980) found the stock of reserves to be a significant explanatory variable for intervention by Canada, Japan, and the United States. This suggests that the authorities were trying to maintain a target level of reserves. Quirk (1977) found that the desire to maintain a target exchange rate helped to explain Japanese intervention. But one variable is predominant in the empirical literature: the change in the exchange rate itself. Authorities lean against the wind, tending to buy their currencies when they are falling and to sell them when they are rising. For example, Quirk (1977) found leaning against the wind to be the most powerful explanation of Japanese intervention, Longworth (1980) found the same for Canada, and Black (1980) found the change in the weighted price of foreign exchange to be a significant explanatory variable for intervention by 7 of the 10 countries he studied.

Let us turn now to our examination of U.S. intervention. The scatter diagram in Figure 1 provides general confirmation of the hypothesis that U.S. authorities leaned against the wind during the 1977-80 period under study. Intervention during day  $t$ ,  $I_t$ , is measured by sales of U.S. dollars in exchange for DM. The change in the spot exchange rate on day  $t$ ,  $\hat{S}_t$ , measures the percentage change in the price of the dollar in terms of the DM. (The day's change is measured as the difference between the closing quotation and the previous day's closing in New York.) The general tendency of the authorities to lean against the wind shows up in the preponderance of observations lying in the first and third quadrants (excluding the 300-plus days when  $I_t = 0$ ).

Before beginning our statistical analysis of leaning against the wind, we observe that there are two outliers in Figure 1. Point A, lying far into the south-east quadrant and thus representing large sales of the DM when the mark was



falling, is the plot for November 1, 1978. At that time, the U.S. government took the position that the dollar was oversold on the market and should be strengthened by intervention. Because this observation is associated with peculiar circumstances and is so far removed from the usual pattern, it is excluded from the initial statistical tests in Table 1. (It will be included in the later statistical work, when we get to our main topic of whether U.S. intervention tended to stabilize the exchange rate between the dollar and the DM.)

The elimination of a specific outlier can, of course, substantially affect statistical results, as we shall see shortly (see footnote 2). It might be justified, however, along the following lines. As noted at the beginning of this chapter, the authorities can have more than one objective when they intervene. Leaning against the wind ties in most closely with the general objective of smoothing exchange-rate movements. On occasion, however, and most conspicuously at the beginning of November 1978, the authorities have declared their intention to pursue another objective, namely, the correction of an exchange rate that they consider to be inappropriate. By eliminating such a special case, we can get a better idea of their general approach to smoothing the exchange rate. In a longer-term context, intervention on November 1, 1978, may be considered a reaction to the declines in the value of the dollar that had taken place in preceding months (see Fig. 2) and thus to the "wind" that had been blowing strongly for some time.

Point *B* in Figure 1 is also excluded as a special case. It refers to January 4, 1978, when it was announced that a Treasury-Bundesbank swap had been arranged and that there would be joint intervention by the U.S. and foreign authorities to counter exchange-market speculation. Although there were no official U.S. transactions on that day, the authorities were in a sense "intervening" by announcing their intention to engage in market transactions. Once again, this observation is consistent with the desire of the authorities to provide strength to the dollar after a period of significant decline.

Table 1 presents regression results after the elimination of these two special cases. The first section includes data for all days except the two outliers; the second section includes only the days when intervention actually took place. Equation T-1 in Table 1 reports the results for the following simple equation:

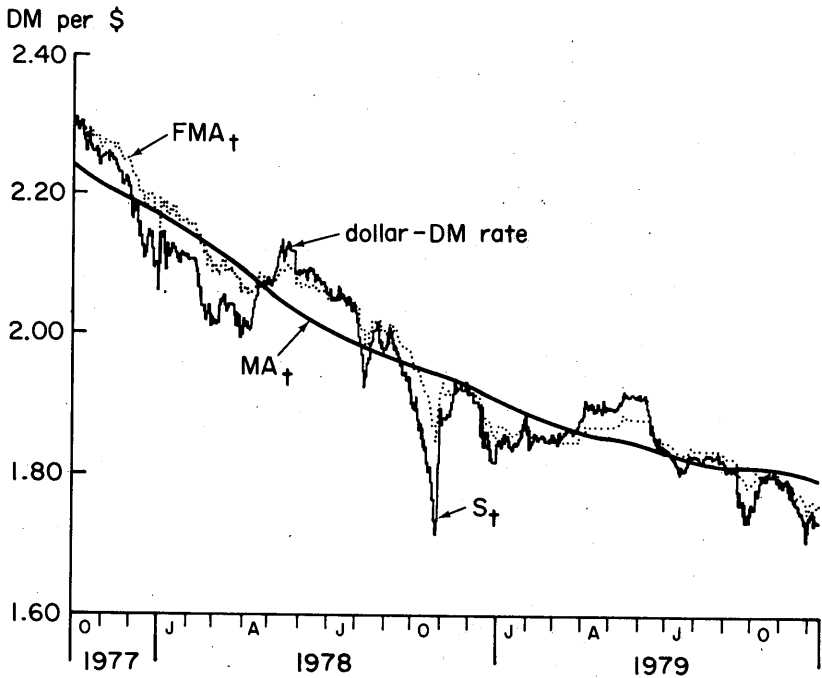
$$I_t = a + bS_t, \quad (1)$$

where  $I_t$  is intervention on day  $t$ , measured as sales of millions of dollars in exchange for DM, and  $S_t$  is the change in the spot exchange rate on day  $t$ , measured as the percentage change in the price of the dollar in terms of the DM.

In equations (T-2) through (T-5) in this table, selected lagged variables are added to equation (1):  $S_{t-1}$  is the change in the exchange rate in the day prior to  $t$ , while  $S_{t-30}$  and  $S_{t-90}$  are the changes in the exchange rate over the 30- and

FIGURE 2

THE DOLLAR IN TERMS OF THE DM, OCTOBER 1977–DECEMBER 1979



90-day periods prior to day  $t$ . All equations except (T-5) are reported after Cochrane-Orcutt correction.<sup>1</sup>

Several results stand out. First, there was an unmistakable tendency for the U.S. authorities to lean against the wind. In each regression, the coefficient of  $S_t$  is positive and significant at the 95 per cent confidence level. Second, intervention clearly did not follow any *simple* leaning-against-the-wind rule. Using only the single independent variable  $S_t$ , we find a low  $\bar{R}^2$  of only 0.13.<sup>2</sup> This

<sup>1</sup> Ordinary-least-squares results are reported in Wonnacott (1982). The Durbin-Watson statistics for equations (T-1) through (T-4) were between 1.06 and 1.11, indicating strong positive serial correlation.

<sup>2</sup> If the two special cases (January 4, 1978, and November 1, 1978) are reintroduced, the  $\bar{R}^2$  in equations (T-1a) and (T-1b) in Table 1 falls to 0.03, reinforcing the conclusion that this simple leaning-against-the-wind equation does not go very far in explaining intervention behavior. Incidentally, exchange-market studies are not marked by high  $\bar{R}^2$ s, even the studies cited earlier whose primary purpose was to explain intervention. Using between 7 and 9 explanatory variables in his equations, Black (1980) found  $\bar{R}^2$ s ranging from 0.23 for the United States to 0.81 for France. Quirk (1977) found  $\bar{R}^2$ s ranging from 0.27 to 0.61 in his 9 explanatory equations of Japanese

TABLE 1  
INTERVENTION AND EXCHANGE-RATE CHANGES  
(dependent variable is  $I_t$ )

Equation No.	Independent Variable					Intercept	$\bar{R}^2$
	$\hat{S}_t$	$\hat{S}_{t-1}$	$\hat{S}_{t-30}$	$\hat{S}_{t-90}$	$I_{t-1}$		
<i>All Days Except Two Outliers; N = 616</i>							
(T-1a)	48.3° (9.84)					-26.0° (-4.04)	0.13
(T-2a)	56.6° (10.07)	16.6° (2.95)				-24.9° (-3.97)	0.15
(T-3a)	50.0° (10.05)		4.6° (2.26)			-22.8° (-3.61)	0.14
(T-4a)	50.2° (10.16)			5.9° (4.27)		-10.3 (-1.47)	0.16
(T-5a)	59.7° (10.57)				0.47° (14.05)	-12.4° (-3.63)	0.33
<i>Only Days When Intervention Occurred; N = 283</i>							
(T-1b)	55.1° (6.60)					-50.9° (-3.57)	0.13
(T-2b)	58.4° (6.57)	10.8 (1.07)				-49.4° (-3.50)	0.13
(T-3b)	55.8° (6.63)		3.8 (0.68)			-46.9 (-3.27)	0.13
(T-4b)	54.9° (6.52)			7.7° (3.06)		-28.9 (-1.97)	0.16
(T-5b)	65.5° (7.01)				0.58° (10.85)	-23.6° (-3.32)	0.39

NOTES:

$t$ -values shown in parentheses.

Regression results shown after Cochrane-Orcutt correction, except for equation (T-5).

\*Statistically significant at 95 per cent confidence level.

result can readily be confirmed by a glance at Figure 1. The points are greatly dispersed around any single line that might be drawn. Third, lagged variables show up significantly. Thus, intervention responds not only to the change in the exchange rate during the day but also to the previous day's change, as reported

intervention. Low  $\bar{R}^2$ s are not surprising in this field. Those engaged in official intervention stress the tone of the market, psychological considerations, and other intangibles not easily fitted into a statistical equation. My own primary purpose (particularly in Chap. 4) is to evaluate whether the authorities stabilized the rate, not to explain their behavior. Thus, my primary pursuit has not been high  $\bar{R}^2$ s, and I warn the reader in advance that my  $\bar{R}^2$ s are low.

in equation (T-2), and to changes over the 30-day and 90-day periods prior to  $t$ , as reported in equations (T-3) and (T-4). Of the lagged variables,  $I_{t-1}$  is most noteworthy; it carries a coefficient of approximately 0.5. On average, half the intervention of any day is repeated on the next. United States authorities intervene when they have been intervening; intervention tends to go in strings.<sup>3</sup>

I argue in the next chapter that the lagged variables introduced into the leaning-against-the-wind rule, particularly in equations (T-3) and (T-4), have significance for whether official intervention is likely to stabilize the rate. But before I look at the implications of leaning against the wind for the stability of the exchange rate, I must pause to consider just what is meant by "stabilization" of an exchange rate.

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<sup>3</sup> Quirk (1977, p. 649) found similar results for Japan. A simple regression of  $I_t$  on  $S_t$  with monthly data gave an  $\bar{R}^2$  of only 0.27. When  $I_{t-1}$  and the volume of exchange-market transactions were added to the equation,  $\bar{R}^2$  rose to 0.60. The high value for the coefficient of  $I_t$  in my results is consistent with the strong serial correlation for the ordinary-least-squares estimates reported in Wonnacott (1982).

### 3 WHAT IS "STABILIZING" INTERVENTION?

The evaluation of exchange-market intervention is complicated by the difficulty of defining what is meant by stabilization. There are at least five possible definitions. Intervention might be deemed to be stabilizing if it:

1. Reduces the variance of the exchange rate around its equilibrium.
2. Reduces the variance of the exchange rate around its welfare-theoretic optimum.
3. Reduces the variance of the exchange rate around its trend.
4. Reduces the amplitude of exchange-rate swings, that is, the difference between the "highs" and "lows."
5. Slows the rate of change of the exchange rate.

There are some similarities among these definitions. For example, if the amplitude of swings is reduced (4), the variance around the trend should be reduced (3). But there are also some clear differences. For example, the variance can be reduced (3) without reducing the amplitude (4) if the peaks and valleys are made sharper without being made higher or lower.

Furthermore, intervention that is stabilizing according to definition (5) may be destabilizing according to other definitions. For example, if the authorities slow an exchange rate that is moving toward its equilibrium or optimum or trend, intervention would be stabilizing according to definition (5) but destabilizing according to definitions (1), (2), or (3). This point was made by Friedman (1953, p. 176) in his early essay on flexible exchange rates. In commenting on the speculation of the 1930s, which had generally been considered destabilizing because it threatened to change exchange rates, he observed:

In retrospect, it is clear that speculators were "right"; that forces were at work making for depreciation in the value of most European currencies relative to the dollar independently of speculative activity; that the speculative movements were anticipating this change; and hence, there is at least as much reason to call them "stabilizing" as to call them "destabilizing."

Because of this conflict, we should discard either definition (1) or (5). My choice is to discard (5), in part because it is defective when there is a trend in the rate. Intervention that slows the rate can keep it away from trend and thus create the need for a very sharp correction later. This scarcely seems to be what is meant by "stabilization." Furthermore, definition (5) may not be sufficiently demanding. Since the authorities in the United States and elsewhere generally lean against the wind when they intervene, there is a presumption that they slow down exchange-rate movements, at least in the short run. Under definition (5), we would be led by a relatively short series of steps to the conclusion that

intervention is stabilizing. By rejecting definition (5), we avoid the conclusion that leaning against the wind is stabilizing simply because it slows down exchange-rate movements.

Of the other four definitions, the second is the tightest, and it has the advantage of collapsing the two questions in the first paragraph of this study into one: if the authorities can stabilize the rate, in the sense of moving it toward the optimum, then they should presumably do so. However, this definition has a major shortcoming, which is shared by definition (1). In both cases, a judgment on whether intervention is stabilizing requires a complete model of the economy. We do not know the equilibrium rate or the welfare-theoretic optimum without a complete model.

Thus, any logically tight evaluation of intervention requires a complete economic model. I do not intend to use such a model, however, for several inter-related reasons. First, any economist should entertain doubts about whether he has the "right" model.<sup>1</sup> Second, formal exchange-rate models are extremely simple, in that they do not include many of the variables, both economic and political, that are inputs into actual decision making. Third, it is not clear that any model we might use should be given precedence over the model explicit or implicit in the minds of the authorities. Put another way, the authorities might reasonably claim that it is illegitimate to judge their policies on the basis of a simple model. The real-world events that they take into account in designing their strategy are in fact complex.

Having given up a logically tight approach, I will focus on a rough-and-ready definition of stabilization:

**Assumption 1:** *Intervention will be judged to be stabilizing if it moves the exchange rate toward its 12-month centered moving average.*

While this assumption is reasonable, it is nevertheless arbitrary. A 12-month moving average is not clearly better than a 6-month or 24-month average; it is simply the most obvious. Furthermore, one might object to the series implicitly defined as perfectly stable under this assumption, that is, a series that tracks its own moving average perfectly. Only with such a series is there no further possibility of stabilization. In other words, a smooth series with a constant change every day is implicitly defined as perfectly stable. Once more, this is reasonable, but it is not the *only* reasonable concept of stability. For example, we might extend Friedman's argument and conclude that the most stable path between

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<sup>1</sup> Meese and Rogoff (1981) have reviewed the difficulties of explaining actual exchange-rate movements with existing exchange-rate models, even when *ex post* values of explanatory variables are used. None of the three major models that they considered outperformed a random walk outside the sample period.



A and B is one where the exchange rate adjusts quickly to its final value at B, that is, one where the exchange rate moves more quickly at first than it moves later.

### *The Effects of Intervention on the Exchange Rate*

If I were using a complete model of exchange-rate determination, I would be able to identify not only the equilibrium exchange rate but also the effects of intervention. In avoiding the use of such a model, I not only give up a tight definition of stabilization but I also have to address the question of how intervention affects the exchange rate.

The simplest theory is based on the assumption that the assets of different nations are perfect substitutes for one another, with one exception. The various national moneys are not perfect substitutes. In this case, the effects of an official purchase of a foreign currency on the exchange market depend entirely on its effects on national money stocks.

On the one hand, the potential monetary effects of exchange-market intervention may be completely sterilized by open-market policy, leaving monetary fundamentals unchanged. The money stock, interest rates, prices, and competitiveness are unaffected, so that the long-run equilibrium exchange rate is likewise unaffected. Even in the short run, the exchange rate is not affected. When assets are perfect substitutes, any incipient change in exchange rates causes private capital flows sufficiently large to prevent the exchange rate from moving away from its long-run equilibrium. The net effects of sterilized intervention consist of compensating changes in official and private asset portfolios: in official portfolios, there is an increase in foreign assets and an equal decrease in domestic assets; in private portfolios, exactly the opposite changes occur.<sup>2</sup>

On the other hand, the purchase of foreign currency need not be sterilized. The money stock increases, the long-run equilibrium price level rises, and the long-run equilibrium exchange value of the home currency declines. As a consequence, asset holders are not willing to buy domestic-currency assets sufficient to bring the present price of the currency back to its initial value. To do so would result in losses as the currency depreciated. Furthermore, if the monetary expansion is associated with a fall in interest rates in the short run, the price of

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<sup>2</sup> Much more detail on the determinants of exchange rates can be found in such works as Bilson (1979), Dornbusch and Krugman (1976), and Genberg (1981) and in the literature surveyed by Gray and Shafer (1981). Genberg (p. 454) mentions an exception to the argument that completely sterilized intervention will have no effect on the spot exchange rate if assets are perfect substitutes. Such intervention can still affect exchange rates if the market takes it as a signal of future monetary changes, that is, if the intervention affects expected future fundamentals and exchange rates in spite of complete current sterilization. This point is also made by Mussa (1980, p. 4).

the home currency will be even lower than the long-run equilibrium price because of the forward-parity condition:

$$\frac{S_a}{F_a} = \frac{1 + r_a}{1 + r_b}, \quad (2)$$

where  $S_a$  and  $F_a$  are the spot and forward prices, respectively, of currency A in terms of currency B; and  $r_a$  and  $r_b$  are the interest returns on short-term securities in countries A and B, respectively, over the term of the forward contract.

In brief, the spot price of the home currency falls not only because fundamental price forces are affecting expectations and therefore the forward rate,  $F_a$ , but also because a lower domestic interest rate reduces the ratio on the right-hand side of equation (2).<sup>3</sup>

If national assets are imperfect substitutes, exchange-market intervention affects exchange rates even in the event of complete sterilization. The intervention has a direct effect on demand and supply conditions in the exchange markets. Private capital flows will not completely offset the intervention: an increase in the attractiveness of domestic assets (a depression of the spot price of the domestic currency relative to the expected future price) is required to induce portfolio adjustments.<sup>4</sup>

I proceed on the basis of

*Assumption 2: The purchase of a currency in the exchange market by the authorities will act to raise the value of that currency in the short run, specifically on the day when the intervention takes place.*

This assumption does not hold in the first case, where nonmoney assets are perfect substitutes and intervention is completely sterilized. It is valid, however, if we make either or both of two assumptions: (a) national assets are imperfect substitutes in private portfolios; (b) intervention is not completely sterilized.

The longer-term effects of intervention depend in large part on whether it is sterilized. In this study I ignore the longer-term effects, even though they may be important in their own right and can also have significant implications for the strength of short-run exchange-rate responses. The principal reason for avoiding this important complication is the intractable problem of identifying

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<sup>3</sup> See Dornbush (1976) for a more extensive discussion in which domestic monetary policy rather than exchange-market intervention is the factor initiating changes. On the short-run and ultimate effects of exchange-market intervention, see Henderson (1979). He comes to the "robust" conclusion (p. 48) that when the foreign currency is purchased, "the home currency depreciates and home nominal income rises."

<sup>4</sup> Again, this is a simplified summary of a complex theoretical question. For more detail on the case where domestic and foreign assets are imperfect substitutes, see Dooley and Isard (1979) and Kenen (1981).

the effects of reserve changes on the money supply, which in turn requires an estimate of what would have happened to monetary magnitudes in the absence of intervention. Thus, I make a third assumption:

*Assumption 3: During any day when no intervention takes place, the exchange rate will return to (or remain at) the free-market rate that would have prevailed had no intervention taken place in previous days.*

Building on these first three assumptions, I come to the key assumption:

*Assumption 4: If the authorities buy a currency when its price is below its 12-month moving average and sell it when its price is above that moving average, they are stabilizing the rate.*

While I have left a number of loose ends, note that assumption (4) is no more problematic than the common view that a market participant who buys when a price is low and sells when it is high will tend to stabilize the price. This common view also requires the assumptions that a purchase or sale will affect the price on the day of the transaction (2) and that longer-term effects may be ignored (3).

While assumption (4) may seem obviously valid, such simple and "obvious" statements may in fact be false. In some markets, a decision to buy whenever the price is low and sell when it is high can create instability. For example, it has been known since the time of Wicksell (1898) that a banking system may in fact destabilize nominal interest rates if it buys bonds when their prices are low and sells them when their prices are high. If a central bank buys bonds when their prices are low, it will increase bank reserves and thereby lay the base for higher aggregate demand, prices, and interest rates. However, bond markets are quite different from foreign-exchange markets. If intervention is permitted to affect the domestic monetary base, intervention to prevent exchange-rate movements will tend to stabilize domestic conditions. Or, more precisely, such intervention will tend to keep a country in line with the country whose currencies are being bought or sold.<sup>5</sup> This, of course, was the logic of the old gold standard: changes in the gold base caused the money supply and prices to change enough to restore balance-of-payments equilibrium at or very close to the parity exchange rates.

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<sup>5</sup> This means that if the objective is to stabilize domestic conditions as well as exchange rates, it is appropriate to pick the currencies of relatively stable countries as the focus for exchange-market policies. This has, in fact, been the practice: U.S. intervention has focused on the DM-dollar rate. The same objective may also explain what seems like a quaint tendency for officials to concentrate on strong currencies. For example, the 1978 *Annual Report* of the Federal Reserve Bank of New York (p. 19, italics added) observes that "the year began with the dollar under *generalized* selling pressure in the foreign exchange markets"—an observation substantiated, not by a reference to a trade-weighted or other general index of the exchange value of the dollar, but rather by a chart showing the exchange value of the dollar in terms of the DM, the yen, and the Swiss franc.

In brief, complications may be raised by the longer-term effects brushed aside by assumption (4). Nevertheless, this assumption does not appear to be particularly problematic when applied to the foreign-exchange market. There is a presumption that short-run exchange-market stabilization will lead toward, rather than away from, a stable system. And there is a very strong practical reason for using assumption (4)—to avoid the need for a complete model of the economy.

### *Leaning Against the Wind and Exchange-Rate Stabilization*

During the early Canadian experience with flexible exchange rates in the 1950s, there was a debate over the effects of leaning against the wind on the stability of exchange rates (Eastman and Stykolt, 1956, 1957, 1958; Kindleberger, 1957; and Wonnacott, 1958; see also Tosini, 1977). The conclusion of that debate was that a consistent leaning-against-the-wind policy would reduce the amplitude of fluctuations and would thus be stabilizing, at least in terms of assumption (4). (However, it would not stabilize a rate moving consistently in one direction.) This conclusion was based in part on assumptions (2) and (3) above.

Once it became precise, this early debate introduced the simplifying assumption that the difference between the observed rate and the free-market rate was a linear function of the amount of intervention ( $I$ ); that is, the effect of intervention was a linear function

$$x - y = c_1 I, \quad (3)$$

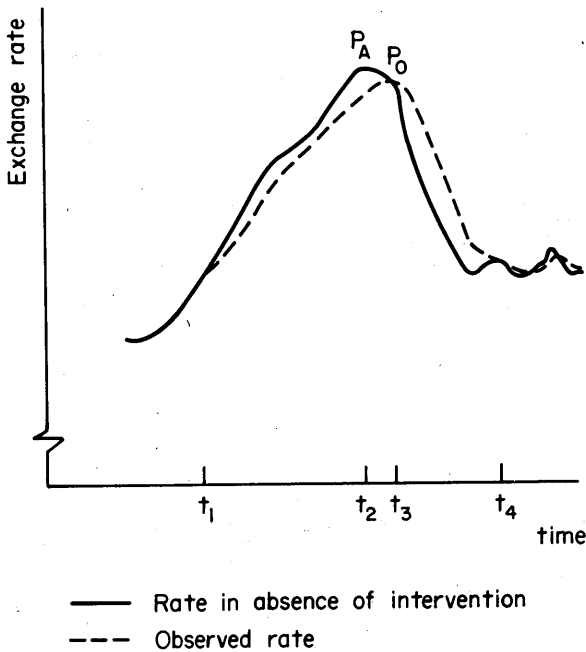
where  $x$  is the free-market exchange rate and  $y$  is the observed rate.

The simplest form of a leaning-against-the-wind rule was considered. Intervention on any day was assumed to be a linear function of the observed exchange-rate movement on that day:

$$I = c_2 \Delta y. \quad (4)$$

The conclusion regarding the reduction of fluctuations is illustrated in Figure 3. The rate in the absence of intervention is illustrated by the solid curve. Suppose that the exchange authority begins its intervention at time  $t_1$ . Because the price is rising, the authority sells, keeping the observed rate (shown in dashes) below the free-market rate. As the observed rate approaches the peak, sales continue; a consistent leaning-against-the-wind policy implies sales as long as the observed rate continues to rise. Therefore, sales keep the observed rate below the free rate for as long as the observed rate continues to rise, that is, until time  $t_3$ . At that point, the observed rate begins to fall and intervention switches from sales to purchases. Note that the observed peak  $P_0$  is lower and

FIGURE 3  
LEANING AGAINST THE WIND



later than the peak  $P_A$  that would have occurred in the absence of intervention. For similar reasons, leaning against the wind will make troughs later and less deep.

Several points are particularly worthy of note:

1. Because this simple leaning-against-the-wind strategy has intervention depend solely on the current day's exchange-rate change, it smooths out a much greater fraction of small day-to-day jiggles, such as those beyond  $t_4$ , than of large swings. This conclusion has been confirmed by Pippinger and Phillips (1973) in their study of Canadian intervention in exchange markets during the 1950s. They found (p. 809) that official intervention reduced two-day fluctuations by almost two-thirds, weekly fluctuations by about one-half, monthly fluctuations by only 8 per cent, and longer fluctuations by even less. Although Canada did not follow a rule as simple as equation (4), such a rule represents a very rough approximation of Canadian intervention, and the results of such a rule would be in broad conformity with the Pippinger-Phillips conclusions.

2. It follows that the authorities have to concentrate heavier intervention around the peaks and troughs if they want to have a sizable effect on the ampli-

tude of major fluctuations. This requires either (a) an ability to judge just when peaks and troughs will occur or (b) a willingness to step up intervention as a one-way movement continues. Point (a) involves forecasting, a complication considered in Chapter 4. Regarding point (b), the positive results shown in Table 1 for  $\dot{S}_{t-30}$  and  $\dot{S}_{t-90}$  indicate that the U.S. authorities did in fact step up intervention as one-way movements continued.

3. Although day-to-day fluctuations can be smoothed out by intervention, a problem arises if large intervention is used to keep exchange-rate changes small in the face of strong market pressures. The authorities may find that they have not only prevented the rate from moving toward its equilibrium but used their available foreign-exchange resources at the beginning of the swing, leaving few resources for resistance late in the swing when leaning against the wind will help reduce the amplitude.

#### *A Digression on Borrowing*

When a country does not own adequate reserves to carry out its intervention plans, a dilemma arises as to whether borrowing should be short-term (swaps) or longer-term (e.g., Carter bonds).

If borrowing is short-term, repayment may be required while a one-way movement of the exchange rate continues. As a consequence, officials may be obliged to withdraw from the market or even to come in on the wrong side during the later stages of a swing, when intervention is particularly appropriate to smooth out a trough. This problem also could arise if there were international understandings on the reestablishment of a target level of reserves within a brief period, such as the 12-month period suggested by Mikesell and Goldstein (1975, p. 21) in their work on intervention rules. Thus, we might conclude that, in order to ensure freedom to intervene as an exchange-rate swing continues, borrowing should be long-term and no commitment should be made to restore a target level of reserves.

However, long-term borrowing is itself problematic. It might be abused to finance fundamental nonreversing payments deficits. The intervening country will then feel little pressure to take corrective steps, either by adjusting domestic macroeconomic policies or by permitting the exchange rate to change.

#### 4 WAS U.S. INTERVENTION STABILIZING? INTERVENTION AND THE 12-MONTH MOVING AVERAGE

To see whether the U.S. authorities have intervened in a stabilizing way according to key assumption (4), we must find out whether they purchased dollars when the dollar's price was abnormally low (i.e., below the 12-month moving average) and sold when its price was abnormally high.

Tables 2 and 3 throw light on the relationship between intervention and percentage deviations of the exchange rate from the centered 12-month moving average ( $DMA_t$ ):

$$DMA_t = \frac{S_t - MA_t}{MA_t} \cdot 100, \quad (5)$$

where  $MA_t$  is the 12-month moving average of the price of the dollar in terms of DM, centered on day  $t$ .<sup>1</sup>

The simplest test of all is reported in column (6) of Table 2. Eighty per cent of the intervention involved sales of dollars when the dollar's price was above the 12-month moving average, or purchases when its price was below the average. That is, for this 80 per cent of intervention,  $I_t$  had the same sign as  $DMA_t$ , and intervention was in the stabilizing direction, according to assumption (4).

Furthermore, if we draw bands around the moving average and consider only days when the spot rates were outside those bands, then the percentage of intervention that was in the stabilizing direction rises to more than 97 per cent as the band is widened to 4 per cent on either side of the moving average. As the deviation from the moving average increased, so did the probability that intervention would be in the stabilizing direction. This is reassuring: it is particularly important for stabilization that intervention occur when the deviations from the moving average are large. (Also, as deviations become large, the arbitrariness of identifying the 12-month moving average as the stable path becomes less important. An exchange rate far above the 12-month moving average is likely to be above any estimate of equilibrium.)

Not only was intervention more likely to be in the stabilizing direction as the deviation from the moving average increased, but intervention was somewhat more likely to occur: observe that the percentage of the days when intervention took place was higher when  $|DMA_t|$  exceeded 4 per cent (Table 2, col. 2).

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<sup>1</sup> It would make sense to use a logarithmic average so that an exponential path would be implicitly defined as perfectly stable, since it would track its moving average exactly. But, for simplicity, an arithmetic average was used in the computations.

TABLE 2  
PERCENTAGE OF INTERVENTION IN THE STABILIZING DIRECTION

<i>Data Set</i> <sup>a</sup>	<i>Including Days When Intervention Was Zero</i>			<i>Only Days When Intervention Occurred</i>		
	<i>No. of Days</i> (1)	<i>% of Days on Which Intervention Occurred</i> (2)	<i>Av. Intervention per Day (\$ million)</i> (3)	<i>No. of Days</i> (4)	<i>Av. Intervention per Day (\$ million)</i> (5)	<i>% of Intervention in Stabilizing Direction</i> <sup>b</sup> (6)
All days	546	48.0	45.7	262	95.2	80.2
Days when $ DMA_t  > 1\%$	385	49.0	42.0	189	85.8	87.3
Days when $ DMA_t  > 2\%$	270	51.1	43.1	138	84.3	91.7
Days when $ DMA_t  > 3\%$	143	51.0	48.2	73	94.4	98.2
Days when $ DMA_t  > 4\%$	47	70.2	61.1	33	87.0	97.4

<sup>a</sup> $|DMA_t| > x\%$  means that data were excluded for days when  $S_t$  was within  $x$  per cent of  $MA_t$ .

<sup>b</sup>Stabilizing intervention, measured in dollars, as a per cent of total intervention, also measured in dollars. (The size of intervention, rather than just the number of days, is taken into account in calculating the percentages.) Intervention deemed to be in stabilizing direction, according to assumption (4), when  $I_t$  and  $DMA_t$  are of the same sign.



TABLE 3  
INTERVENTION AND DEVIATIONS OF THE EXCHANGE RATE FROM ITS MOVING AVERAGE  
(dependent variable is  $I_t$ )

<i>Data Set</i> <sup>a</sup>	<i>Including Days When Intervention Was Zero</i>				<i>Only Days When Intervention Occurred</i>			
	<i>Equation No.</i>	<i>DMA<sub>t</sub></i> (1)	<i>Intercept</i> (2)	$\bar{R}^2$ (3)	<i>Equation No.</i>	<i>DMA<sub>t</sub></i> (4)	<i>Intercept</i> (5)	$\bar{R}^2$ (6)
All days	(T-6a)	12.0° (4.57)	-28.3° (-3.91)	0.03	(T-6b)	19.6° (4.35)	-60.7° (-4.29)	0.06
Days when $ DMA_t  > 1\%$	(T-7a)	11.0° (4.67)	-19.3° (-2.54)	0.05	(T-7b)	17.9° (4.28)	-42.2° (-2.72)	0.08
Days when $ DMA_t  > 2\%$	(T-8a)	10.9° (5.39)	-21.8° (-2.96)	0.09	(T-8b)	17.5° (4.81)	-43.4° (-2.82)	0.14
Days when $ DMA_t  > 3\%$	(T-9a)	10.1° (3.62)	-20.0 (-1.57)	0.08	(T-9b)	15.9° (3.79)	-44.3° (-2.10)	0.16
Days when $ DMA_t  > 4\%$	(T-10a)	8.9° (2.65)	-22.5 (-1.13)	0.12	(T-10b)	12.5° (3.00)	-30.7 (-1.21)	0.21

NOTES:

*t*-values shown in parentheses.

Regression results shown after Cochrane-Orcutt correction.

<sup>\*</sup>Statistically significant at 95 per cent confidence level.

<sup>a</sup> $|DMA_t| > x\%$  means that data were excluded for days when  $S_t$  was within  $x$  per cent of  $MA_t$ .

However, the amount of intervention during days when intervention actually took place remained reasonably stable at about \$90 million, regardless of the deviations from the moving average (col. 5). To sum up Table 2: as the deviations from the moving average increased, intervention was more likely to be in the stabilizing direction (col. 6); the authorities were somewhat more likely to intervene (col. 2); but they did not increase the size of their daily intervention (col. 5).

The regression results in Table 3 confirm the tendency of the authorities to intervene in the stabilizing direction. The coefficients of  $DMA_t$  (cols. 1 and 4) are consistently positive and significant.<sup>2</sup>

In passing, note that Table 3 illustrates the advantage of using daily data. When equation (T-6) of that table was rerun using monthly data, the coefficient lost its statistical significance—and did so by a wide margin.<sup>3</sup> If I had only monthly data and used normal 95 per cent confidence levels, I would reject the deviation of the exchange rate from its moving average as an explanation for intervention, unaware of the strong evidence that appears when daily data are available.

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<sup>2</sup> Because the average amount of intervention remained quite stable as  $DMA_t$  increased (Table 2, col. 5), the coefficients of  $DMA_t$  in columns 1 and 4 of Table 3 fall as  $DMA_t$  becomes larger. However, the rate of fall is reduced by the greater frequency of stabilizing intervention (Table 2 col. 6).

<sup>3</sup> The probability of obtaining a  $t$  statistic as great as that observed for the coefficient rose from 0.01 using the daily data to 0.24 using monthly data. My much stronger results with daily than monthly data support an explanation suggested by Genberg (1981) for the negative results of his study. On the basis of empirical work using monthly and quarterly data, he found (p. 471) "very weak evidence of the effectiveness of [sterilized] intervention." He was puzzled "why intervention in foreign exchange markets is so common" in spite of its apparent ineffectiveness. In explanation, Genberg suggested that "the time horizon of central banks for intervention policy [may be] typically much shorter than the one adopted in this paper and the studies reviewed here. Intervention may be carried out mainly in order to influence day-to-day, or even shorter-term, swings in exchange rates and therefore may be reversed over periods as long as a month or a quarter. In this case, studies that are based on these longer time horizons may fail to detect any effects of intervention even though . . . the policies did have the desired effects."

## 5 DID THE AUTHORITIES "OUTPREDICT" THE MARKET?

It is often argued that to stabilize the exchange rate the authorities must make profits by outpredicting the market. In simple terms, the argument goes as follows:

1. To stabilize the market, the authorities buy when the price is low and sell when it is high. As a result, they make profits.

2. When market participants foresee a price rise, they will bid up the current price, eliminating the possibility for profits. Thus, in order to make profits, the authorities must be able to foresee price rises not foreseen by the market. (This proposition need not hold where exchange controls restrain private transactions. Rather, it applies to unregulated markets.)

3. Therefore, if the authorities are going to stabilize a market, they will have to (a) outpredict the market and (b) use this information to intervene in a profit-making way, by buying when the price is low and selling when it is high.

For some time, it has been recognized that this argument is not logically tight. Specifically, even though the first point is plausible, it is not necessarily true. Most obviously, if the authorities intervene to remove all fluctuations around a horizontal trend, they will stabilize the rate without making profits, since they will buy and sell at the same price. (For more complex illustrations of the lack of a tight relationship between profits and stabilization, see Kemp, 1964, pp. 259-263.) Nevertheless, the relationship between profits and stabilization seems so plausible that we may usefully pursue it. The evidence presented above suggests that the U.S. authorities tended to stabilize the rate. In doing so, did they (a) outpredict the market and (b) use their prediction in a profit-making way?

Of course, the authorities might be able to use inside information to outpredict the market but intervene in pursuit of objectives quite independent of profit making. That is, they might try to stabilize the exchange rate and/or the economy but not try to make profits. Clearly, profit making is not the principal objective of domestic open-market operations, and there is no reason to believe that it should be the principal objective of international operations either—unless one takes the view that profit making is necessarily related closely to exchange-rate stabilization.

It would be difficult to identify outpredicting that was unassociated with a profit motive unless the authorities made their predictions public. However, it is the double hypothesis (outprediction, and use of predictions by officials to make profits) with which we are concerned, and this double hypothesis *can* be tested. To do so, we must first go back and sharpen the argument in simplified statements (1) and (2) above. It is not precise to say that the authorities make profits by buying low and selling high. The problem is that interest rates differ

between countries, and the advantage of purchasing a currency at a low price might be offset or more than offset by the lower interest on securities denominated in the currency being purchased.

The difference in interest rates is taken into account in equation (2) in Chapter 3. The forward rate can be viewed both as the market's best guess about the future rate and as including compensation for the interest-rate differential. Buying a currency simply because the forward rate signals a rise may not result in profits: if the spot rate rises to the rate signaled by the forward rate, the capital gain will be offset by the loss in interest income. To make a profit, one must buy when the currency is going to rise by more than enough to compensate for the interest-rate differential. In other words, one must buy when it is going to rise by more (or fall by less) than predicted by the forward rate. One must outpredict the market by buying when the "forward error" is positive:

$$E_t^n = \frac{F_t^n - S_{t+n}}{S_{t+n}} \times 100, \quad (6)$$

where  $E_t^n$  is the error in the forward rate for  $n$  months beyond time  $t$ , measured as a percentage;  $F_t^n$  is the forward rate quoted at time  $t$  for  $n$  months into the future; and  $S_{t+n}$  is the actual spot rate  $n$  months after time  $t$ .

Because the forward rate takes into account the relative cost of funds, the size of the error measures the profit potential from each unit of intervention. Thus, we can test profitable outprediction of the market by looking at the sum of the products:

$$\text{Outprediction indicator} = \sum_{t=1}^N I_t \cdot E_t^n. \quad (7)$$

If the authorities profitably outpredict the market,  $I_t$  is positive when  $E_t^n$  is positive. Dollars are sold when the forward rate is "too high," in the sense that the spot price of the dollar turns out thereafter to be lower than forecast by  $F_t^n$ . Thus, equation (7) is positive. This proves to be the case for the 1-month forward error. For  $E_t^1$ , the sum of the negative products was 89.3 per cent of the sum of the positive products, giving an overall positive sum. But for the 3-month error, the product is negative. The sum of the positive products was 94.9 per cent of the sum of the negative products, giving a negative result. Thus, equation (7) provides little basis for concluding that the authorities were either better or worse predictors than the market.

Alternatively, a regression line,  $I_t = aE_t^n$ , can be fitted to see if the coefficient  $a$  is positive. The results from such regressions are shown in equations (T-11) and (T-12) of Table 4. (Unlike earlier tests, these regressions were run using only data from the days on which intervention took place. We are interested in

TABLE 4  
INTERVENTION AND ERRORS IN THE FORWARD RATE  
(dependent variable is  $I_t$ )

Equation No.	Independent Variable			Intercept	$\bar{R}^2$
	$E_t^1$	$E_t^3$	DFMA <sub>t</sub>		
(T-11)	5.3 (1.19)			-71.7° (-4.51)	0.002
(T-12)		7.1° (2.09)		-81.4° (-4.99)	0.01
(T-13)			29.6° (4.19)	-40.3° (-2.51)	0.06
(T-14)	1.3 (0.30)		29.1° (4.00)	-41.6° (-2.51)	0.06
(T-15)		2.6 (0.76)	27.5° (3.66)	-47.1° (-2.59)	0.06

NOTES:

$t$ -values shown in parentheses.

Regressions use only data for days when intervention occurred.

Regression results shown after Cochrane-Orcutt correction.

\*Statistically significant at 95 per cent confidence level.

whether authorities outpredicted the market on the days when they actually intervened.) We find that the coefficient is positive in both cases, for the 1-month and 3-month periods. However, only the coefficient of the 3-month error met the standard 95 per cent confidence level. All in all, evidence that the authorities outpredicted the market is weak at best.

Another possibility would be to look directly at the profit or loss of the intervening authority. There are, however, two major problems with this approach. First, the cost of funds to a treasury or central bank may be less than to the market; profits may be shown simply as a result of cheap funds rather than of outprediction. Second and more important is the problem of how to deal with the unrealized capital gain or loss on the inventory of foreign exchange or on outstanding Carter bonds. The importance of this complication during the period under study may be seen from the profit picture presented in the report, "Treasury and Federal Reserve Foreign Exchange Operations," *Federal Reserve Bulletin* (March 1980), p. 193: valuation losses are much larger than trading profits. Because the size of unrealized capital gains or losses is very sensitive to the precise beginning and ending points, the direct measurement of profits is particularly questionable. The precise choice of period is much less important if equation (7) is used.

A final profitability problem that is ignored in equation (7) is the cost of obtaining information. Even if a central bank or others made gross profits as indicated by this equation, these profits might be consumed or more than con-

sumed in research or other information-generating expenditures. I simply disregard this problem; all profit statements should be considered exclusive of the costs of obtaining information.

How do we explain the stabilizing activity of the authorities, in the sense that they pushed the rate toward its 12-month moving average, if they did not on average significantly outpredict the market?

We consider two possible explanations: (1) Sufficient market information is available at time  $t$  to provide the basis for stabilizing intervention without forecasting. (2) While the authorities may not have generally outpredicted the market—as indicated by the ambiguous results when equation (7) was calculated—they may have outpredicted the market during the periods that were strategic for stabilizing activity as we identify it, that is, when the exchange rate deviated widely from its moving average.

1. *Stabilization without Forecasting? Information Available at Time  $t$ .* At time  $t$ , half the information necessary to construct the centered 12-month moving average is of course available, and the other half—spot quotations for the coming 6 months—is not. The market does, however, provide an estimate of the average for the next 6 months in the form of the 3-month forward quotation,  $F_t^3$ .<sup>1</sup> Thus, we can use market data available at time  $t$  to calculate a forecast moving average at time  $t$  ( $FMA_t$ ):

$$FMA_t = \frac{MA_t^6 + F_t^3}{2}, \quad (8)$$

where  $MA_t^6$  is the moving average of the spot rates for 6 months prior to  $t$ .

The percentage deviation of the current spot rate from this average ( $DFMA_t$ ) can be readily calculated:

$$DFMA_t = \frac{S_t - FMA_t}{FMA_t} \times 100. \quad (9)$$

Now, suppose that this deviation is used to guide intervention policy, either explicitly or implicitly. The authorities will sell dollars when the exchange value of the dollar is above its *forecast* moving average and buy them when it is

<sup>1</sup> Additional information is also readily available in the form of the 1-month and 6-month forward rates. These quotations might also be used, with the calculation

$$\frac{F_t^1 + F_t^3 + [(F_t^3 + 2F_t^6)/3]}{3}$$

substituted for  $F_t^3$  in equation (8). However, a spot check revealed that this alternative calculation made a difference only in the third or fourth decimal point, so it was not used because of the more cumbersome calculations required.

below. In following such a strategy, will they also sell when the price of the dollar is above the *ex post* 12-month moving average and buy when it is below, and thus behave in a stabilizing way according to our assumption (4)?

The evidence suggests that the answer to this question is yes, at least for the period under study. In Figure 4 and Table 5 (col. 3 and 4), observe that the *ex post* DMA, generally turns out to carry the same sign as DFMA. (*FMA<sub>t</sub>* and *MA<sub>t</sub>* were also included in Figure 2 above.)

This leaves the question of whether intervention was in fact consistent with the guideline provided by *DFMA<sub>t</sub>*. Again, the answer is yes. A scatter diagram showing the relationship between *DFMA<sub>t</sub>* and exchange-market intervention is provided in Figure 5. The preponderance of intervention that falls in the first and third quadrants is striking, suggesting that intervention is consistent with *DFMA<sub>t</sub>*. (This does not mean that a calculation of this deviation was explicitly made; the authorities may simply have been looking at the path of the spot rate over the preceding 6 months and at the forward rate.)

Indeed, Figure 5 is in some ways more revealing than the results of the formal statistical methods reported below. The tilted hourglass shape formed by the

FIGURE 4

DEVIATIONS FROM THE MOVING AVERAGE AND FROM THE FORECAST MOVING AVERAGE,  
OCTOBER 1977-DECEMBER 1979

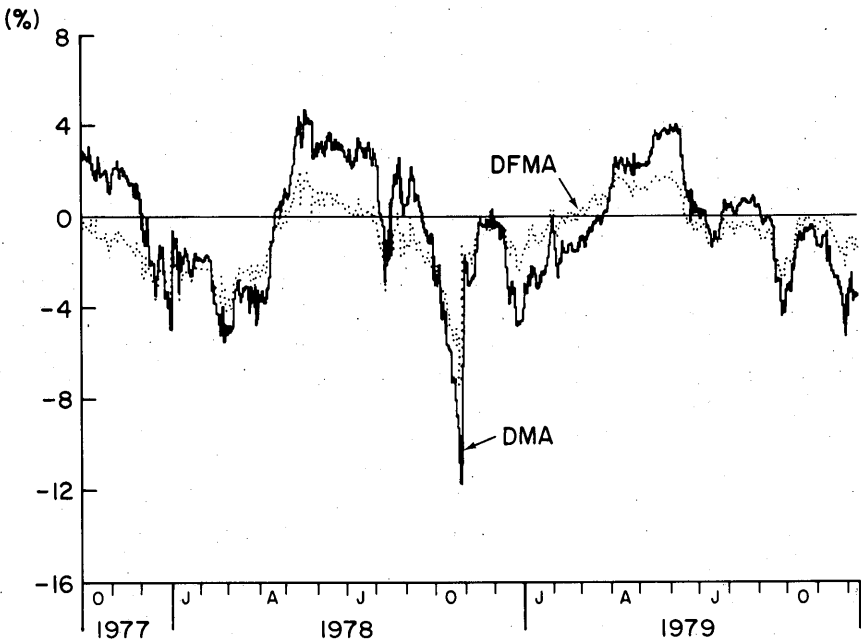


TABLE 5  
STABILIZING INTERVENTION AND  $DFMA_t$

Data Set <sup>a</sup>	% of Intervention in Stabilizing Direction <sup>b</sup> (1)	% of Stabilizing Intervention Consistent with $DFMA_t$ <sup>b</sup> (2)	% of Days When $DFMA_t$ of Same Sign as $DMA_t$	
			All Days <sup>c</sup> (3)	Only Days When Intervention Occurred <sup>c</sup> (4)
All days	80.2	99.9	74.0	81.3
Days when $ DMA_t  > 1\%$	87.3	100.0	85.2	89.4
Days when $ DMA_t  > 2\%$	91.7	100.0	91.5	94.2
Days when $ DMA_t  > 3\%$	98.2	100.0	99.3	100.0
Days when $ DMA_t  > 4\%$	97.4	100.1	100.0	100.0

<sup>a</sup>  $|DMA_t| > x\%$  means that data were excluded for days when  $S_t$  was within  $x$  per cent of  $MA_t$ .

<sup>b</sup> The size of daily intervention is taken into account. (For further detail, see footnote b to Table 2.)

<sup>c</sup> No account is taken of the size of intervention; number of days is the sole basis for calculating percentages.

data in Figure 5 indicates a *very* strong relationship between  $DFMA$  and intervention in one important respect: intervention was unlikely to go against the indication given by  $DFMA$ . (That is, there are few observations in the second and fourth quadrants.)

Furthermore, as can be seen in column (2) of Table 5, intervention in the stabilizing direction (as indicated after the fact by  $DMA$ ) was almost invariably also in the direction indicated at the time by  $DFMA$ . The only exception occurred when  $|DMA_t|$  was less than 1 per cent. Whenever  $|DMA_t|$  exceeded 1 per cent, *all* intervention that was judged to be stabilizing *ex post* according to key assumption (4) was in the direction indicated at the time by  $DFMA_t$ .

However, the wide dispersion of data within the first and third quadrants of Figure 5 shows that, while intervention tended to be of the *sign* indicated by  $DFMA$ , the strength of the  $DFMA$  indicator is not a powerful determinant of the *strength* of intervention.

Although it is obvious that no single line will fit the data in Figure 5 well, it is also obvious that there is a positive relationship between intervention and  $DFMA$ . This general impression is confirmed by the regression results in equations (T-13), (T-14), and (T-15) back in Table 4: in each case, the coefficient of  $DFMA$  is statistically significant.

When the forward errors are added to the regression in equations (T-14) and (T-15), testing whether the authorities were also outforecasting the market as

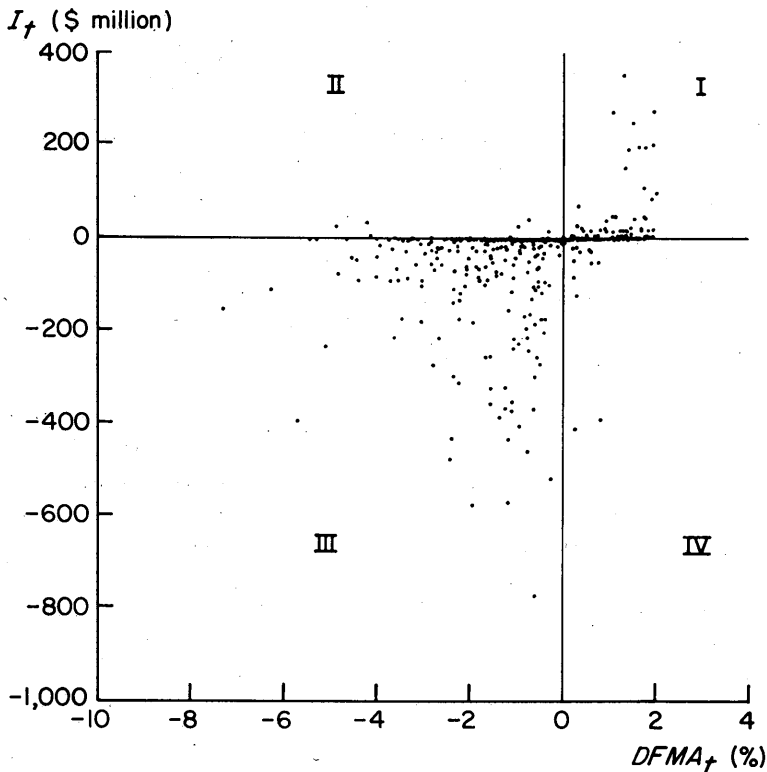


well as responding to  $DFMA_t$ , the results are negative. In neither case is the coefficient of the error statistically significant. This last result is in line with my earlier conclusion that evidence of official outpredictions of the market is weak at best.

The main conclusions of this chapter can be briefly summarized. Intervention was consistent with the signal given by  $DFMA_t$ , particularly in the sense that intervention seldom had the opposite sign from  $DFMA_t$ , as indicated by the hourglass shape in Figure 5.  $DFMA_t$  and  $DMA_t$  are also related: intervention that was stabilizing after the fact according to  $DMA_t$  was almost always in the direction indicated at the time by  $DFMA_t$ . Thus, one possible explanation for the stabilizing intervention observed earlier may be a tie running from  $DFMA_t$  to intervention to  $DMA_t$ .

If the authorities can stabilize the exchange rate in this manner with information available at the time in  $DFMA_t$ , then either it is possible to stabilize the

FIGURE 5  
INTERVENTION AND DEVIATIONS FROM THE FORECAST MOVING AVERAGE



rate without making profits or markets are inefficient in the sense that private participants are overlooking the possibility for profit inherent in  $DFMA_t$ . I will return shortly to the possibility of market inefficiency.

2. *Specific Outpredictions?* There remains the other possibility, that the authorities may have outpredicted the market during the important periods when the exchange rate deviated widely from its moving average.

It is possible that the authorities were capable of generally outpredicting the market but did not use this capability to make profits during periods when the rate was nearly "normal" (that is, near its moving average) because they were interested in some other objective, such as making a market or improving the "tone" of the market. (Recall that the tests are incapable of identifying the forecasting record of the authorities as such. They can only identify whether the authorities outpredicted the market *and* used their predictions to intervene in a profitable way.) Then, when the rate deviated sharply from "normal," the objective of intervention may have switched to stabilizing the rate, which led also to profitable behavior.

Alternatively, the authorities may have been incapable of outpredicting the market most of the time but were able to do so when the market was substantially oversold or overbought, as indicated after the fact by a large deviation from the moving average. Statistically, these two alternatives cannot be distinguished. In either case, outprediction will be observed only when the deviations from the moving average are large.

The evidence in Table 6 is not sufficiently clear to permit a strong conclusion on this question. We saw earlier in Table 4 that the forward errors were not significant as an explanation of intervention when  $DFMA_t$  was included. Table 6 presents similar equations, for periods when  $|DMA_t|$  exceeded 2, 3, and 4 per cent. For both the 2 and 3 per cent cutoff points, the results correspond to the results of Table 4: forward errors are not significant when included with  $DFMA_t$ . However, when the range is widened to 4 per cent, it is the coefficient of  $DFMA_t$  that loses its significance, while one of the errors,  $E_t^1$ , retains significance.

Two possible explanations come to mind for these results. One is that when deviations from the 12-month moving average were particularly large, the authorities did indeed significantly outpredict the market, as indicated by the significant coefficient for  $E_t^1$ . The alternative is that the results are unstable because of collinearity between the forward errors and  $DFMA_t$ . If this was in fact the case, then markets were inefficient over this period, in the sense that data currently available, used to calculate  $DFMA_t$ , had power in explaining the forward errors. This alternative explanation is supported by the results in Table 7: when the errors are regressed on  $DFMA_t$ , the coefficients are uniformly significant. (For recent work on market inefficiency, see Dooley and Shafer, 1982.)

TABLE 6  
 SPECIFIC OUTPREDICTIONS?  
 (dependent variable is  $I_t$ )

Equation No.	Independent Variable			Intercept	$\bar{R}^2$
	$DFMA_t$	$E_t^1$	$E_t^3$		
Days when $ DMA_t  > 2\%$ :					
(T-16)	27.2° (4.33)			-27.6 (-1.57)	0.11
(T-17)		9.3 (1.89)		-53.8° (-2.93)	0.02
(T-18)			8.7° (2.63)	-66.4° (-3.62)	0.04
(T-19)	26.5° (3.72)	1.0 (0.19)		-28.1 (-1.59)	0.11
(T-20)	24.9° (3.29)		2.0 (0.55)	-32.5 (-1.66)	0.11
Days when $ DMA_t  > 3\%$ :					
(T-21)	26.1° (3.37)			-30.1 (-1.21)	0.11
(T-22)		16.1° (2.77)		-60.5° (-2.88)	0.09
(T-23)			9.1° (2.21)	-70.8° (-3.12)	0.05
(T-24)	24.5° (2.19)	1.7 (0.16)		-31.6 (-1.22)	0.12
(T-25)	29.2° (2.50)		-2.2 (-0.36)	-25.3 (-0.87)	0.11
Days when $ DMA_t  > 4\%$ :					
(T-26)	18.3° (3.37)			-27.6 (-1.21)	0.13
(T-27)		17.1° (3.50)		-38.4 (-1.89)	0.24
(T-28)			11.7° (2.56)	-51.3° (-2.19)	0.15
(T-29)	-1.0 (-0.09)	17.8° (2.06)		-39.7 (-1.54)	0.24
(T-30)	8.8 (0.67)		7.2 (0.88)	-37.4 (-1.16)	0.15

NOTES:

$t$ -values shown in parentheses.

Regressions use only data for days when intervention occurred.  
 Regression results shown after Cochrane-Orcutt correction.

\*Statistically significant at 95 per cent confidence level.

TABLE 7  
INEFFICIENT MARKETS?

Equation No.	Dependent Variable	DFMA <sub>t</sub>	Intercept	$\bar{R}^2$
All days:				
(T-31)	$E_t^1$	0.4° (4.28)	1.0 (1.47)	0.06
(T-32)	$E_t^3$	0.5° (4.22)	1.6 (1.20)	0.06
Days when  DMA <sub>t</sub>   > 1%:				
(T-33)	$E_t^1$	0.6° (5.12)	0.8 (1.22)	0.12
(T-34)	$E_t^3$	0.6° (4.86)	1.4 (0.88)	0.11
Days when  DMA <sub>t</sub>   > 2%:				
(T-35)	$E_t^1$	0.7° (5.67)	0.5 (0.91)	0.19
(T-36)	$E_t^3$	0.9° (6.52)	1.3 (0.82)	0.23
Days when  DMA <sub>t</sub>   > 3%:				
(T-37)	$E_t^1$	0.9° (7.23)	0.8 (1.34)	0.42
(T-38)	$E_t^3$	1.4° (8.57)	1.5 (1.12)	0.51
Days when  DMA <sub>t</sub>   > 4%:				
(T-39)	$E_t^1$	1.1° (8.35)	0.6 (0.49)	0.69
(T-40)	$E_t^3$	1.2° (6.71)	0.9 (1.05)	0.59

NOTES:

*t*-values shown in parentheses.

Regressions use only data for days when intervention occurred.

Regression results shown after Cochrane-Orcutt correction.

°Statistically significant at 95 per cent confidence level.

## 6 INTERVENTION POLICY: A TENTATIVE SUGGESTION

Recall that in column (2) of Table 5 intervention that was stabilizing according to assumption (4) was almost invariably consistent with the signal given by  $DFMA_t$ . This suggests a way of improving the performance shown in column (1) of that table. Specifically, intervention might be made more uniformly stabilizing by using  $DFMA_t$  as a policy filter: once a tentative intervention decision has been made, intervention will actually proceed only when it is consistent with the signal given by  $DFMA_t$ . If such a filter had been used during the period under review, authorities would have eliminated all the mistakes they made, that is, all their destabilizing activity in the sense of assumption (4), when the exchange rate deviated more than 1 per cent from the *ex post* moving average.

Furthermore, the results seem sufficiently strong to suggest that additional, and stronger, intervention might be attempted using  $DFMA_t$  as an indicator for intervention. Clearly, this study has not made a complete case for such a conclusion. In particular, I have addressed only question (1) at the opening of this paper and have ignored the equally important issue of whether stabilizing intervention is desirable. My own inclination would be to answer yes, on the general ground that all the merits are not on one side in the debate over fixed or flexible exchange rates. An intermediate floating system with intervention may be best *if* the authorities can in fact stabilize the rate. On this last point, the results of this study are encouraging. I hasten to add, however, that the results of this study must be considered tentative; they may be due to the peculiarities of the brief period studied. Note, in particular, in Figure 4 that  $FMA_t$  and the moving average were on opposite sides of the spot rate during the first few months of the period. This suggests that intervention on the basis of the  $DFMA_t$  signal might have been destabilizing in earlier periods. Furthermore, Genberg's (1981) survey of the literature on intervention concludes (p. 470) that "empirical evidence on the influence of intervention policy is mixed." More recent work also provides mixed results. Using the profits criterion, Taylor (1982) concludes that authorities on average were unsuccessful in their attempts to stabilize exchange rates during the 1970s. On the other hand, Argy (1982, pp. 73-74) comes to a generally favorable conclusion regarding intervention by Germany, Japan, and the United Kingdom. In all three countries (particularly Germany and the United Kingdom), intervention pushed the exchange rate toward its moving average.

## 7 CONCLUSIONS

Clearly, our conclusions must be tentative, because only a short period was studied. In that period, however:

1. U.S. intervention tended to stabilize the DM-dollar rate in the sense of assumption (4).

2. There is only weak evidence that the authorities outpredicted the market to stabilize the rate, although they may have done so during critical periods when the rate deviated sharply from its *ex post* moving average.

3. A forecast moving average, constructed from observations over the previous six months plus the forward quotation, may be useful in intervention policy. Most notably, all significant intervention errors would have been avoided if the authorities had used deviations from the forecast moving average as a policy filter (i.e., had decided against intervention whenever planned intervention conflicted with the sign of  $DFMA_t$ ).

Two final conclusions may be advanced, but even more tentatively:

4. The authorities might consider more active intervention, using  $DFMA_t$  as an indicator for intervention.

5. Private market participants might find  $DFMA_t$  worth following because of its tendency to predict forward errors.

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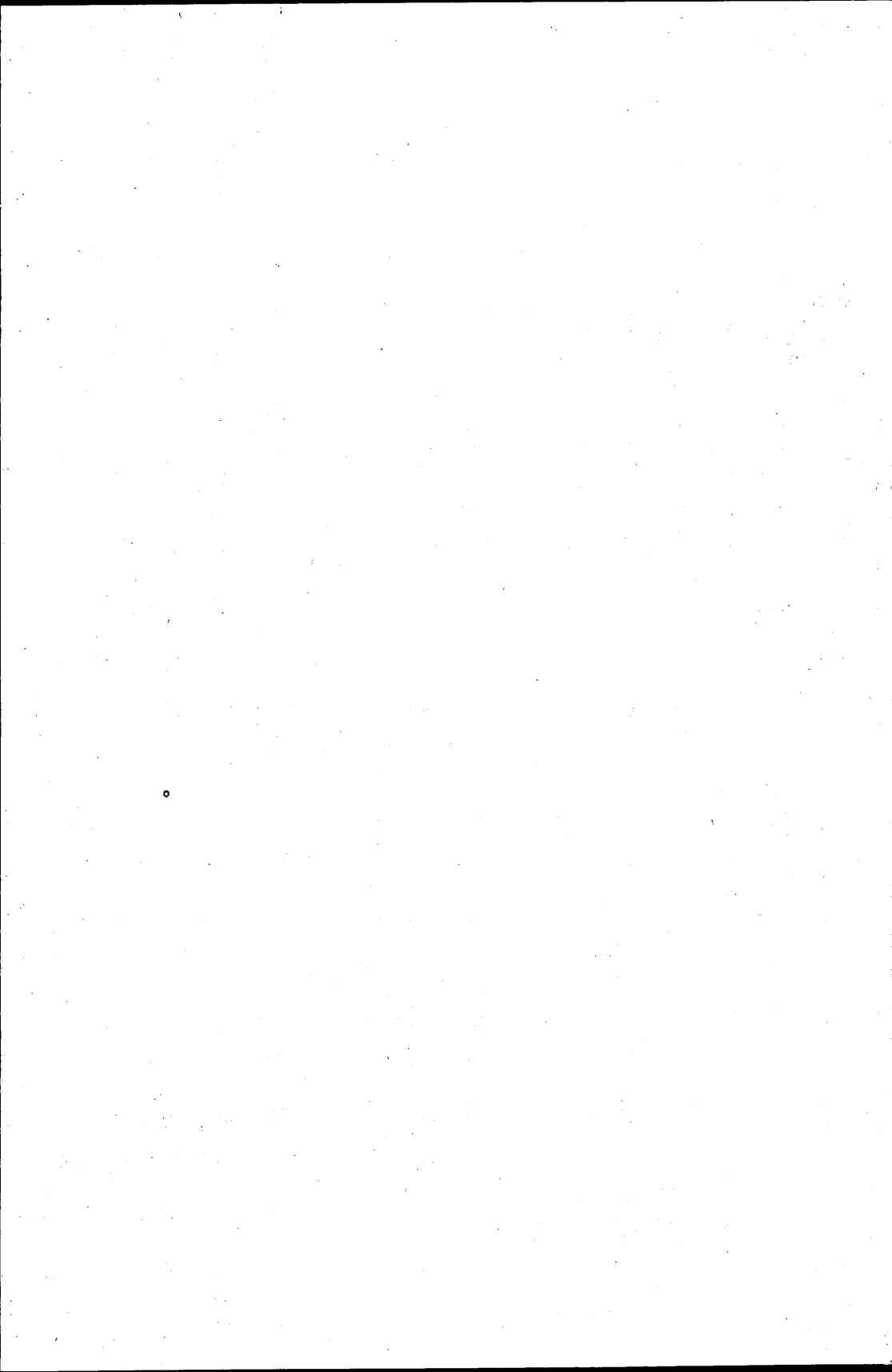
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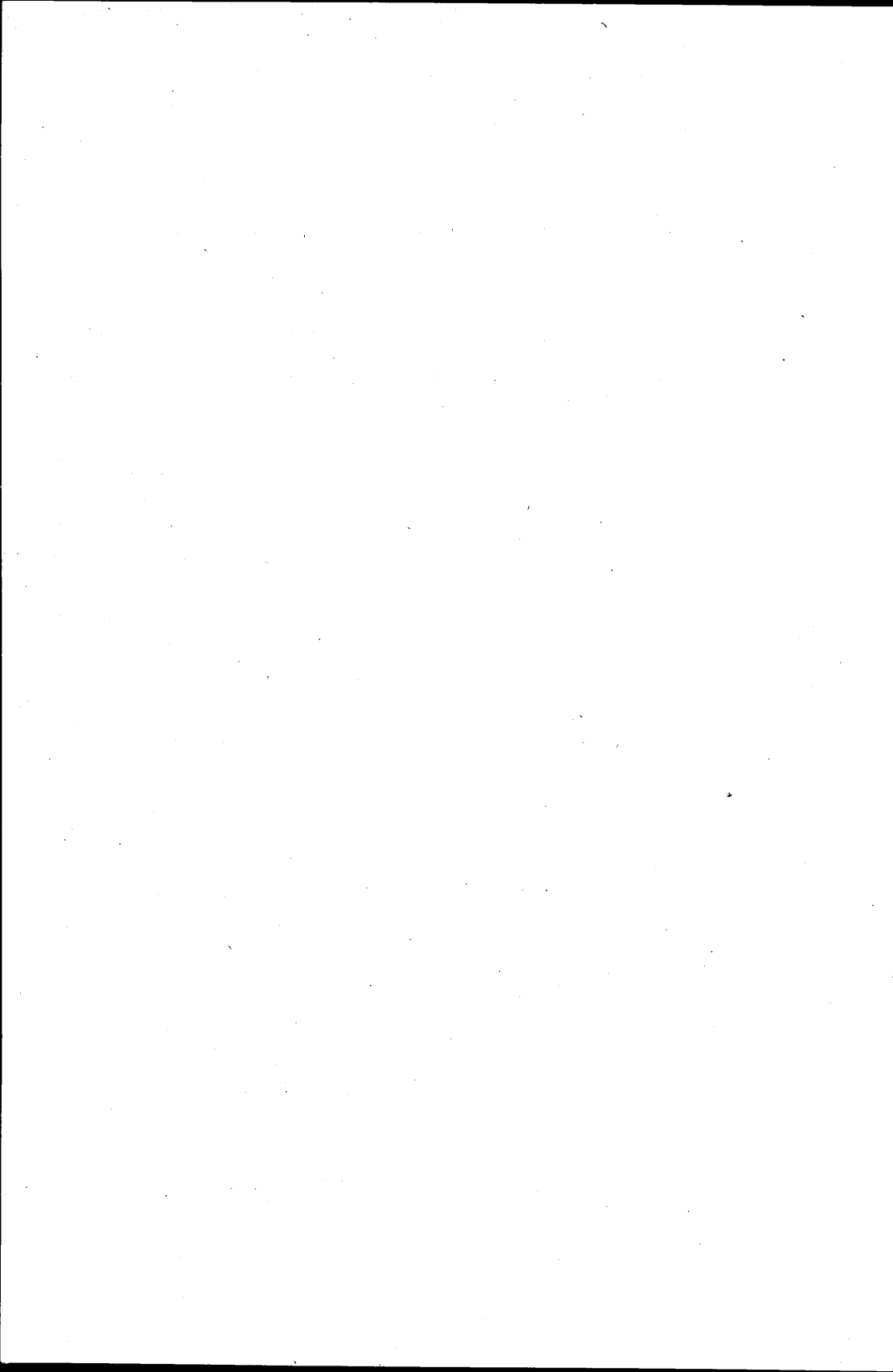
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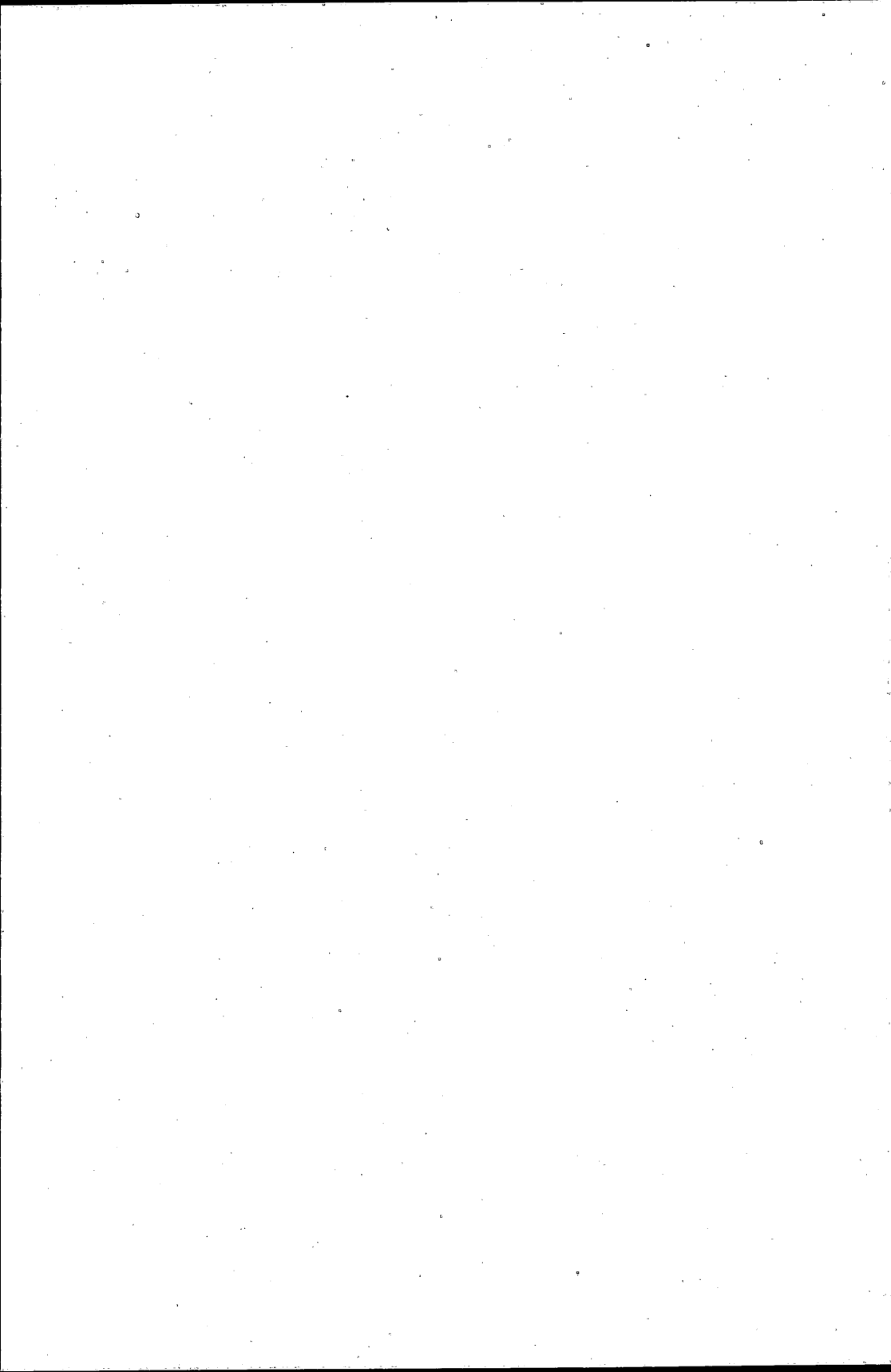
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